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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

# Effects of Baku-Tbilisi-Ceyhan crude oil pipeline on the water quality in Yumurtalık Coast of the Iskenderun Bay

# Bakü-Tiflis-Ceyhan petrol boru hattının İskenderun Körfezi, Yumurtalık kıyılarında su kalitesi üzerindeki etkileri

**Mehmet Aksu* • Aslı Başaran • Özdemir Egemen**

*Ege University, Faculty of Fisheries, Department of Hydrobiology, 35100 Bornova, Izmir-Turkey*
**Corresponding author: mehmet.aksu@ege.edu.tr*

**Özet**: Bakü-Tiflis-Ceyhan Petrol Boru Hattı (BTCOP) Hazar Denizi petrolünü Türkiye'nin Ceyhan Limanına, oradan da Avrupa pazarına ulaştırmak için inşa edilmiştir. Projenin amacı petrolün güvenli ve ekonomik olarak ulaştırılmasıdır. Bu çalışmanın amacı ise, BTC boru hattının ulaştığı Yumurtalık kıyılarında yer alan Ceyhan Deniz Terminalinin su kalitesi üzerindeki etkilerinin izlenmesidir. Bu amaçla, Temmuz 2007, Ağustos 2009 ve Temmuz 2011'de ikisi referans istasyonu olmak üzere dört istasyondan örneklemeler yapılmıştır. Tuzluluk, sıcaklık ve yoğunluğun derinliğe bağlı değişimleri CTD cihazı ile ölçülmüştür. Ayrıca su kolonunda pH, berraklık, çözünmüş oksijen (DO), besleyici elementler (nitrit+nitrat-azotu, amonyum-azotu, fosfat fosforu ve silis) ve klorofil a değerleri ölçülmüştür. Sonuç olarak, çalışma alanında ötrofikasyon riski görülmemiştir. Fosfat limitleyici besleyici elementtir. Söz konusu alanda BTCOP faaliyetlerinin su kalitesi üzerinde önemli bir etkisi yoktur. Bununla birlikte, su kalitesinde meydana gelebilecek bozulmanın fark edilmesi ve gerekli önlemlerin alınabilmesi için sürekli izlemenin yararı büyüktür.

***Anahtar kelimeler***: Su Kalitesi, izleme, klorofil a, Yumurtalık, Bakü-Tiflis-Ceyhan

**Abstract:** The Baku-Tbilisi-Ceyhan Oil Pipeline (BTCOP) was constructed to transport oil from the Caspian Sea to the Ceyhan Port of Turkey and from there to European markets. The aim of the project is the establishment of a safe and economically viable transport system of oil. The purpose of this study is monitoring of the effects of Ceyhan Marine Terminal of BTCOP on water quality characteristics in the Yumurtalık Coast. With this aim, samplings were accomplished in July 2007, August 2009 and July 2011 at four stations, two of them served as reference. Salinity, temperature and density variations with depth were measured with CTD device. In addition, pH, turbidity, dissolved oxygen (DO), Nutrients (nitrite+nitrate-nitrogen, ammonium-nitrogen, phosphate-phosphorus and silicate) and chlorophyll-a were measured along the water column. In conclusion, there is no eutrophication risk at the study area in light of our findings. Phosphate is the limiting nutrient. There was no evident impact of BTCOP activities on water quality at the area concerned. Nevertheless, continuous monitoring is essential to detect any deterioration on the water quality and to take necessary measures.

***Keywords***: Water quality, monitoring, chlorophyll a, Yumurtalık, Baku-Tbilisi-Ceyhan

## INTRODUCTION

Turkey forms a natural energy bridge between the source-rich countries of the Caspian basin, Middle East and the world markets. With this vision, the East-West Energy Corridor Project was elaborated. The East-West Energy Corridor aims at transporting the Caucasian and Central Asian energy resources to western markets through safe and alternative routes. The East-West Energy Corridor Project mainly includes the Baku-Tbilisi-Ceyhan Oil Pipeline (BTCOP), the South Caucasian Natural Gas Pipeline (Baku-Tbilisi-Erzurum Natural Gas Pipeline) and the Turkmenistan-Turkey-Europe Gas Pipeline projects (Anonymous, 2013). BTCOP was constructed to transport the Azeri oil from the Caspian Sea to the Ceyhan Port of Turkey and from there to European markets. The construction began in April 2003 and was completed in 2005. BTCOP is a 1,768 kilometers long crude oil pipeline. The first oil was loaded at the Ceyhan Marine Terminal (Haydar Aliyev Terminal) onto a tanker in June 2006. There are two jetties for loading at the Terminal (Fig 1).

The project area is located in the northern coast of Iskenderun Bay. The Bay is presently experiencing rapid industrial growth and increase in population. Population expansion, increased industry, agriculture and tourism create significant environmental impacts on the coastal ecosystem. Present industrial activities include chemical plants, steel, fertilizer, soda, glass, paper, textile, mechanical and energy production. Untreated or pre-treated municipal wastewaters from various settlements along the coast and the major towns of Iskenderun and Antakya via Asi River are potential sources of marine pollution (Anonymous, 2011). The Ceyhan River which is one of the main rivers on the Mediterranean coast of Turkey discharges its nutrient reach waters into the bay (Polat, 2002). Civilian and military marine transport linked to the harbours of Mersin, İskenderun and Taşucu, shipbuilding activities, oil storage and pipeline terminals at Yumurtalık, Ceyhan and Dörtyol are other activities with potential impact on the marine environment (Anonymous, 2011).

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The purpose of this study is monitoring of the effects of BTCOP on water quality characteristics at the Ceyhan Marine Terminal located in Yumurtalık Coast.

## MATERIALS AND METHOD

### Study Area

The study area is located in the northern coast of Iskenderun Bay. The bottom topography of the Bay varies linearly, increasing from 20 m in the inner part to 90 m towards the mouth. Depths at the study area are between 24 to 38 meters. There are two jetties at the Terminal.

In order to determine physical and chemical properties of the study area, 2 stations (St. 1 and 2) were chosen around the two jetties. Additionally, 2 reference stations (St. R1 and R2) were also selected to be able to compare the results (Figure 1).

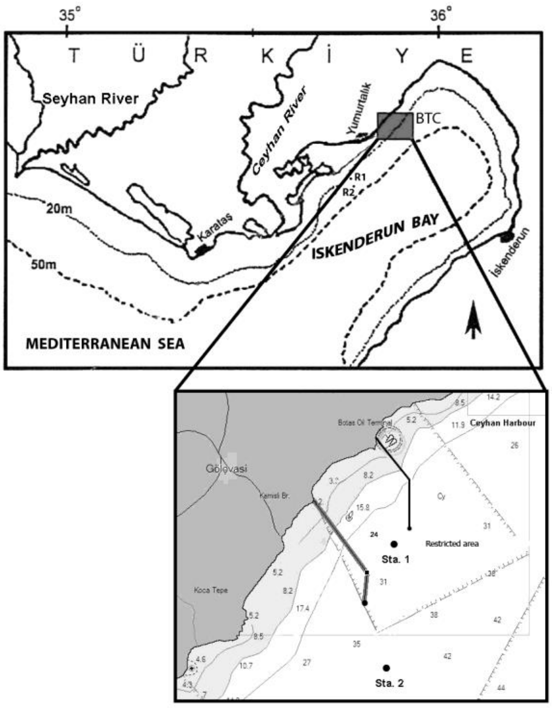


**Figure 1**. Location of the study area and the sampling stations in the Yumurtalık Coast of the Iskenderun Bay

### Collecting samples

Samplings were performed in July 2007, August 2009 and July 2011 at the stations. Seawater samples were taken from surface, mid water and bottom by Nansen sampling bottle to determine pH, turbidity, dissolved oxygen (DO), basic nutrients (nitrite+nitrate-nitrogen, ammonium-nitrogen, phosphate-phosphorus and silicate) and chlorophyll-a. In addition, Salinity, temperature and density values were measured with CTD device regarding the water depth (water column).

### Methods

pH was measured by handheld pH meter (YSI 100), turbidity was measured by turbidimeter (WTW, Turb 355 IR/T) while DO was measured according to Winkler Titration Method on the site. Collected water samples were then taken to the laboratory in cold chain for further analyses. Samples were kept in the refrigerator until analyses. Nutrients were determined spectrophotometrically using HACH DR 2000. Chlorophyll a values were determined spectrophotometrically using acetone extraction method (Strickland and Parsons, 1972).

Normal distribution of the data was tested by Kolmogorov-Smirnov and homogeneity of the variances tested by Levene Statistical analyses. Kruskal-Wallis and Mann Whitney U Tests were performed to detect differences between sampling stations, sampling years and surface and bottom water.

## RESULTS

### CTD data

Results of sea water physical parameters measured with CTD device at four stations with respect to vertical profiles are presented in Figures 2 and 3. Water temperature values ranged from 25.84-30.55°C throughout the monitoring period in the study area. Average and standard error values were calculated as 28.51±0.04°C. Minimum temperature was observed at station 2 bottom water in 2007, maximum was at station 1 surface water in 2009. Salinity along the water column ranged from 39.19 to 40.05 PSU. Average value was 39.66±0.00 PSU. Minimum value was observed at station R1 surface water in 2009, maximum at station 2 bottom water in 2011. Density values changed between 24.84 and 26.71 kg/m$^3$ with average value of 25.76±0.01 kg/m$^3$.

### Physico-chemical parameters

Some physico-chemical parameters measured during 2007, 2009 and 2011 are given in Table 1.

During the three sampling period, pH values ranged from 7.93 to 8.58 (average: 8.28±0.04). Minimum value was recorded at station 2 mid-water, while maximum pH value was measured at station 2 surface water. Statistical differences between the sampling years were important for pH values ($p<0.001$).

Dissolved oxygen concentrations varied between 5.60 and 7.60 mg/L (average: 6.55±0.08 mg/L). Minimum value was measured at station 2 mid and bottom water. Maximum concentration of DO was measured at station R1 bottom water. Station 2 DO values were found to be significantly different from that of stations R1 and R2 ($p<0.05$). Significant difference between the sampling years was also found for DO values. DO concentrations of 2011 sampling was different from that of 2007 and 2009 ($p<0.01$)

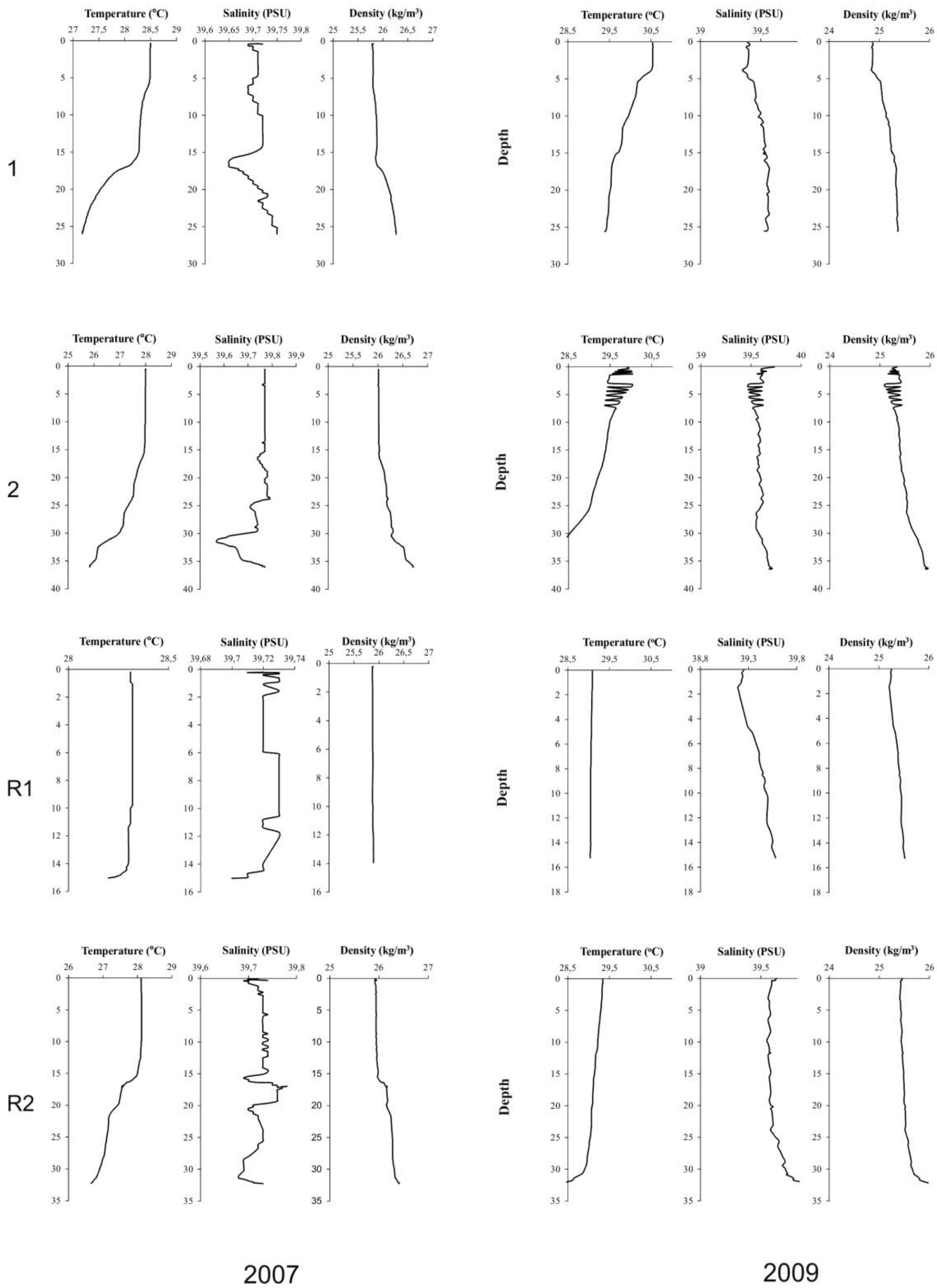


**Figure 2.** CTD results of sampling stations in 2007 and 2009 in the Yumurtalık Coast of the Iskenderun Bay

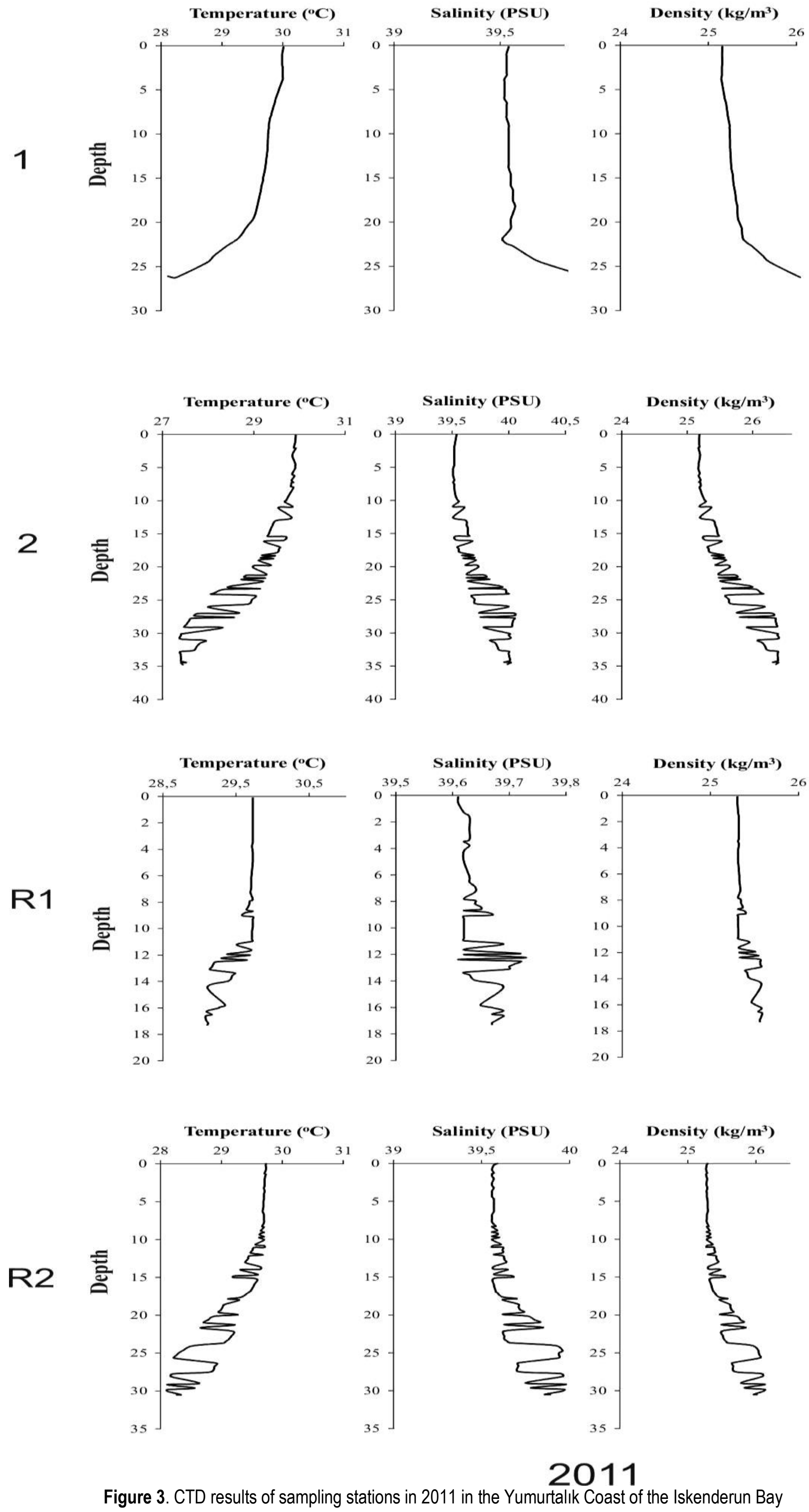


**Figure 3**. CTD results of sampling stations in 2011 in the Yumurtalık Coast of the Iskenderun Bay

**Table 1.**Variations of pH, DO and turbidity values along the water column during the sampling period in the Yumurtalık Coast of the Iskenderun Bay

| Stations | Depths | pH | | | DO (mg/L) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 |
| 1 surface | 0.5 | 8.54 | 8.32 | 7.99 | 6.0 | 6.0 | 6.8 | 0.81 | 1.41 | 3.50 |
| 1 mid- water | 12.0 | 8.52 | 8.35 | 7.99 | 6.0 | 6.0 | 7.2 | 0.67 | - | 4.29 |
| 1 bottom | 25.0 | 8.49 | 8.40 | 7.95 | 6.4 | 6.4 | 7.2 | 0.34 | - | 6.30 |
| 2 surface | 0.5 | 8.58 | 8.32 | 7.97 | 6.0 | 6.0 | 6.8 | 0.70 | 2.24 | 3.03 |
| 2 mid-water | 12.0 | 8.52 | 8.32 | 7.93 | 5.6 | 5.6 | 6.4 | 0.54 | - | 4.49 |
| 2 bottom | 37.0 | 8.57 | 8.30 | 8.04 | 5.6 | 5.6 | 6.4 | 0.90 | - | 13.53 |
| R1 surface | 0.5 | 8.50 | 8.29 | 8.00 | 7.2 | 7.2 | 6.8 | 0.92 | 2.37 | 10.57 |
| R1 mid-water | 8.0 | 8.52 | 8.34 | 8.00 | 7.2 | 7.2 | 6.8 | 0.38 | - | 4.47 |
| R1 bottom | 16.0 | 8.52 | 8.32 | 8.08 | 6.4 | 6.4 | 7.6 | 0.95 | - | 3.72 |
| R2 surface | 0.5 | 8.51 | 8.32 | 7.98 | 6.4 | 6.4 | 6.8 | 0.79 | 1.57 | 9.30 |
| R2 mid-water | 15.0 | 8.52 | 8.36 | 8.00 | 6.8 | 6.8 | 7.2 | 0.59 | - | 5.65 |
| R2 bottom | 30.0 | 8.50 | 8.34 | 7.97 | 6.8 | 6.8 | 6.8 | 0.68 | - | 10.56 |

**Table 2.** Variations of nitrite+nitrate, ammonium and phosphate concentrations during the sampling period in the Yumurtalık Coast of the Iskenderun Bay

| Stations | Depths | $NO_2$+$NO_3$-N (µM) | | | $NH_4$-N (µM) | | | $PO_4$-P (µM) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 |
| 1 surface | 0.5 | 0.31 | 4.44 | 3.97 | 0.17 | nd | 0.34 | 0.07 | 0.14 | 0.21 |
| 1 mid- water | 12.0 | 5.67 | 5.04 | 4.78 | nd | 1.93 | 0.34 | 0.07 | 0.14 | 0.21 |
| 1 bottom | 25.0 | 2.77 | 5.64 | 5.00 | 0.09 | 0.57 | 0.34 | 0.07 | 0.21 | 0.14 |
| 2 surface | 0.5 | 2.90 | nd | 5.13 | 0.34 | 1.04 | 0.77 | nd | 0.07 | 0.28 |
| 2 mid-water | 12.0 | 11.29 | 7.58 | 5.31 | 0.09 | 1.25 | 1.03 | nd | nd | 0.21 |
| 2 bottom | 37.0 | 9.42 | 1.10 | 4.55 | 0.34 | 0.99 | 1.20 | 0.07 | 0.07 | 0.21 |
| R1 surface | 0.5 | 2.99 | 1.07 | 4.42 | 0.69 | 1.56 | 2.32 | 0.21 | 0.14 | nd |
| R1 mid-water | 8.0 | 19.24 | 7.40 | 4.96 | 0.26 | 0.89 | nd | 0.21 | 0.21 | 0.14 |
| R1 bottom | 16.0 | 26.11 | 1.76 | 5.22 | 0.26 | 0.05 | 1.81 | 0.21 | 0.21 | 0.07 |
| R2 surface | 0.5 | 1.38 | 1.89 | 4.96 | 0.17 | 1.41 | 0.17 | 0.07 | 0.28 | 0.07 |
| R2 mid-water | 15.0 | 10.27 | 8.04 | 4.29 | 0.09 | 0.99 | 0.17 | 0.07 | 0.55 | 0.14 |
| R2 bottom | 30.0 | 10.85 | 2.02 | 4.11 | 9.80 | 1.35 | 0.34 | 0.07 | 0.21 | 0.14 |

nd: non detected

**Table 3.** Silicate and chlorophyll a variations during the sampling period in the Yumurtalık Coast of the Iskenderun Bay.

| Stations | Depths | $Si(OH)_4$-Si (µM) | | | Chlorophyll a (µg/L) | | |
|---|---|---|---|---|---|---|---|
| | | 2007 | 2009 | 2011 | 2007 | 2009 | 2011 |
| 1 surface | 0.5 | 1.42 | 11.28 | 0.32 | nd | 0.130 | 0.650 |
| 1 mid- water | 12.0 | 4.93 | 14.12 | 0.21 | nd | 0.610 | 0.650 |
| 1 bottom | 25.0 | 3.24 | 8.04 | 0.21 | 0.310 | 1.300 | 1.170 |
| 2 surface | 0.5 | 3.38 | 5.61 | 0.21 | nd | 0.302 | nd |
| 2 mid-water | 12.0 | 10.95 | 9.73 | 0.42 | nd | 0.413 | 0.260 |
| 2 bottom | 37.0 | 8.24 | 5.95 | 0.21 | nd | 0.650 | 0.910 |
| R1 surface | 0.5 | 3.45 | 13.99 | 0.11 | nd | 0.260 | 0.260 |
| R1 mid-water | 8.0 | 13.04 | 7.37 | 0.00 | nd | 0.420 | 0.130 |
| R1 bottom | 16.0 | 22.30 | 3.99 | 0.11 | nd | 0.780 | 0.910 |
| R2 surface | 0.5 | 3.24 | 5.81 | 0.11 | nd | 0.114 | 0.650 |
| R2 mid-water | 15.0 | 7.5 | 8.11 | 0.21 | nd | 0.116 | 0.390 |
| R2 bottom | 30.0 | 10.41 | 3.92 | 0.21 | nd | 0.253 | 1.040 |

nd: non detected

Turbidity values ranged from 0.34-13.53 NTU. In 2009 survey only surface water turbidity values were measured. Minimum value was observed at station 1 bottom water, maximum was at station 2 bottom.

### Nutrients and Chlorophyll a

Nutrients and chlorophyll a variations during the study are presented in Tables 2 and 3.

Nitrite+nitrate concentrations changed between 0.31 and 26.11 µM (average: 5.71±0.85 µM) during the study. Minimum value was detected at station 1 surface water in 2007. Maximum concentration was found at station R1 bottom water in 2007. At station 2 surface water, nitrite+nitrate concentration was not detected (nd) due to lower concentration than the detection limit of the method.

Ammonium-nitrogen values ranged from 0.05 to 9.80 µM (average: 0.92±0.27 µM). Minimum concentration was measured at R1 bottom water in 2009. Maximum value was recorded at R2 bottom water in 2007. The statistical differences between the sampling years were important ($p<0.05$).

Phosphate-phosphorus concentrations varied between 0.07 and 0.55 µM (average: 0.14±0.01 µM), showed no significant statistical differences between the years ($p>0.05$). Minimum values were observed mostly in 2007 (Table 2). On the other hand, maximum value was measured at R2 mid water in 2009.

Silicate concentrations ranged from 0.11 to 22.30 µM (average: 6.79±1.24 µM) in the area concerned. Lowest values were observed in 2011 sampling. Maximum concentration was recorded at R1 bottom in 2007. Significant differences were found between the sampling years ($p<0.001$).

Chlorophyll a concentrations varied between 0.114 and 1.300 µg/L (average: 0.35±0.06 µg/L) during the study. In 2007, chlorophyll a concentrations were under the detection limit at all the sampling stations, accept station 1 bottom water. In accordance, statistical differences between the years were found to be significant ($p<0.001$). Maximum value was recorded at station 1 bottom water in 2009

## DISCUSSION

Turbidity of seawater shows the condition that degree of optical clearness of seawater is affected by the existence of dissolved matters and suspended particles. Turbidity values throughout sampling period varied between 0.34 and 13.53 NTU (average: 2.72±0.59 NTU). Although higher values were measured in 2011 than that of other years, it was found that there was no important impact according to water quality criteria for turbidity (Anonymous, 2011).

The surface water temperatures at all stations were almost identical, with only a minor difference. There was 1-2 °C difference between the surface and the bottom water temperatures at station 2 and R2. There were no differences between surface and bottom water at station R1 due to its lower depth as compared to the other stations. Salinity and density values were homogenous through the water column at this station (Salinity: 39.7 PSU, Temperature: 28.3 °C, Density: 25.8 kg/m$^3$). No significant differences between the stations were recorded for salinity values. The variances (0.1-0.2 PSU) between the surface and bottom water salinities were unimportant. Salinity levels in the study area ranged from 39.19 to 40.05 PSU (average: 39.66±0.00 PSU).

pH values for this region varied from 7.93 to 8.58 (average: 8.28±0.04). According to guidelines for interpreting water Quality data, pH criteria for aquatic life varies between 6.5-9.0.

In the study area, it was observed that surface waters were rich in DO and the water column was almost saturated with it. Yılmaz et al. (1992) reported that the İskenderun Bay was physically dynamic, the oxygen-rich Mediterranean open seawaters enter the bay, circulate and return by flushing the Bay. During the monitoring period of 2007-2011, the dissolved oxygen concentrations exhibited slight decrease through the water column but the values were not under 5 mg/L even at the depth close to bottom. Tuğrul et al. (2011) reported that DO concentrations varied between 180-250 µM in the Northeastern Mediterranean which is compatible with our results.

The three nutrient elements: ammonium, nitrate, silicate have their lowest concentration at the surface (except phosphate max. 0.55 µM). Nutrient concentrations in fact did not increase much with depth (Tables 2-3). In this study the maximum concentration level of available nutrients are relatively high when compared with the open sea values (6 µM nitrate, 0.25 µM phosphate, 10-12 µM silicate) of the Eastern Mediterranean Sea (Krom et al. 2010). Some relatively high values of nutrients observed during the monitoring period are believed to be resulting from river discharges and agricultural activities. The Ceyhan river discharges nitrate rich water into the Iskenderun Bay. Nitrate concentrations of Ceyhan River are higher than those of the other rivers of the area (Tuğrul et al. 2007). The inorganic N concentrations found during our study were higher than recorded by Polat, 2002. In this study nitrate concentrations ranged from 0.31 -26.11 µM. Kontas et al. (2004) (0.13 – 27.0 µM) and Sunlu et al. (2012) (nd – 21.35 µM) reported similar nitrate concentrations in the Izmir Bay.

The eastern Mediterranean has oligotrophic characteristics mainly due to low levels of available nutrients which are essential for primary producers (Krom et al. 1991). Specially, phosphate levels were very low. Atmospheric deposition of ammonia and phosphate are 5 times higher than those of river discharges in the Eastern Mediterranean. Accordingly ratio of N/P after atmospheric inputs (N/P: 117) is higher than the redfield ratio of 16:1 for N/P. (Krom et al. 2010). When ratios of N/P examined, higher values were found at R1 (N/P: 56) and R2 (N/P: 73) than those at stations 1 (N/P: 37) and 2 (N/P: 25). In addition, observing ratios of N/P greater than 16 at all stations show that primary production in the area was controlled by phosphate ions and terrestrial inputs were not important at the time of the study. Consequently, nutrient loads are not likely to be resulting from the Ceyhan Terminal.

Higher ammonium concentrations than ours were reported by Kukrer (2009) (0.23-22.8 µM) and Sunlu et al. (2012) (nd-40.94 µM) in the Izmir Bay. Aksu (2012), reported lower concentrations (nd-5.42 µM) in the Iskenderun Bay than that of this study: 0.05-9.8 µM.

Doğan-Sağlamtimur and Tuğrul (2006), investigated river discharges in the Mersin Bay and reported that inorganic phosphate concentration varied between 0.01-0.08 µM. Polat and Uysal (2009) reported that phosphate varied between 0.05-0.76 µM in the Iskenderun Bay. In this study phosphate concentrations varied between 0.07-0.55 µM. Higher phosphate concentrations (nd-31.43 µM) than ours were reported by Sunlu et al. (2012) in the Izmir Bay.

Chlorophyll a, an indicator of biological production ranged from 0.114 to 1.300 µg/L in the study which was performed in summer months. Mean value of three years calculated as 0.35±0.01 µg/L. Polat and Uysal (2009) reported chlorophyll a values between 0.11-2.86µg/L in the Iskenderun Bay. Aksu (2009) measured chlorophyll a concentrations between 0.07-

4.59 µg/L in Izmir Bay, Aegean Sea. Yılmaz et al. (1992) reported chlorophyll a values between 0-6.5 µg/L and commented that "In summer months the water stratified and nutrients are made available by active regeneration at deeper layers; the chlorophyll a concentration is relatively low in this season". Consequently, the Eastern Mediterranean show ultra-oligotrophic feature and its annual primary production is 60-80 mgC/m$^2$year (Psarra et al. 2000).

In the study area, silicate concentrations varied between 0.11-22.30 µM (mean of three years: 6.97±1.2µM). The silicate ions come from terrestrial inputs and are high in the Eastern Mediterranean Rivers. In this study, performed in summer months, measuring highest concentration at station R1 bottom water indicate that there is terrestrial input near to the station and since this station is shallower than the others silicate ions dissolving from sediment with the increasing temperature may also contribute to the amount of silicate. Kaymakçı-Basaran and Egemen (2007) in a study performed in summer time in the Mediterranean Coast of Turkey reported that mean silicate value was 10.97±2.1 µM.

In conclusion, there was no eutrophication risk at the study area in light of our findings. Phosphate was the limiting nutrient. There was no evident impact of BTCOP activities on water quality at the area concerned. Nevertheless, continuous monitoring is essential to be able to detect any deterioration on the water quality and to take necessary measures.


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## REFERENCES


Aksu, M., 2009. Investigation of the Impacts of some Fish Farms on Marine Environment in the Izmir Bay. *Ege Journal of Fisheries and Aquatic Sciences*, 26(4): 271–279.

Aksu, M., 2012.The Effects of Sugozu Power Plant on Water Quality in the Iskenderun Bay, Eastern Mediterranean. *Journal of Animal and Veterinary Advances*, 11 (2): 224-228. doi: 10.3923/javaa.2012.224.228

Anonymous, 2011.*Baku-Tbilisi-Ceyhan Crude Oil Pipeline Project Environmental Monitoring and Consultancy Services for the Operation Phase of Turkısh Section*. DOKAY Marine Sediment and Marine Ecology Survey Report.196 p.

Anonymous, 2013. Economic Outlook of Turkey <http://www.mfa.gov.tr/prospects-and-recent-developments-in-the-turkish-economy.en.mfa> (20.02.2013)

Doğan-Sağlamtimur, N., Tuğrul, S., 2006. Seasonal variation of phosphor forms and nutrients: Continental shelf of Erdemli, Northeast Mediterranean, Year of 2004.(*in Turkish*) In: Turkish Coast Conference 2006, Proceedings Book, E, Özhan(Editor), pp. 517-525.

Kaymakçı-Basaran, A., Egemen, Ö., 2007. Nutrient Distribution in the Mediterranean Coast of Turkey. *Rapp. Comm.int.MerMéditt.*, 38:676.

Kontas, A., Kucuksezgin, F., Altay, O., Uluturhan, E., 2004. Monitoring of eutrophication and nutrient limitation in the İzmir Bay (Turkey) before and after Wastewater Treatment Plant. *Environment International,* 29, 1057-1062. doi: 10.1016/S0160-4120(03)00098-9

Krom, M.D., Brenner, S., İsrailov, L., Krumgalz, B., 1991. Dissolved nutrients, preformed nutrients and calculated elemental ratios in the Southeast Mediterranean Sea. *Ocenology Acta,* 14 (2):189-194.

Krom, M.D., Emeis, K-C., Van Capellen, P., 2010. Why is the Eastern Mediterranean phosphorus limited? *Progress in Oceanography* 85, 236-244. doi: 10.1016/j.pocean.2010.03.003.

Kukrer, S., 2009.*Investigating the effects of creeks to eutrophication in İzmir* Bay on cleaning process. Ph.D. Thesis, Ege University, 162 pp.

Polat, S., Uysal, Z., 2009. Abundance and biomass of picoplanktonic Synechococcus (Cyanobacteria) in a coastal ecosystem of the Northeastern Mediterranean, the Bay of İskenderun.Marine Biology Research, 5: 363-373. doi: 10.1080/17451000802512275.

Polat, S., 2002. Nutrients, Chlorophyll a and Phytoplankton in the İskenderun Bay (Northeastern Mediterranean*). Marine Ecology*, 23 (2):115-126. doi: 10.1046/j.1439-0485.2002.02753.x

Psarra, S., Tselepides, A., Ignatiades, L., 2000. Primary productivity in the oligotrophic Cretan Sea (NE Mediterranean): Seasonal and inter annual variability*. Progress in Oceanography 46* (2-4), 187-204 doi: 10.1016/S0079-6611(00)00018-5

Strickland, J.D.H., Parsons, T.R., 1972. *A practical handbook of seawater analysis. Fisheries Research Board of Canada, Bull*. 167, Ottowa, 310 p.

Sunlu, F.S., Sunlu,U., Buyukısık, B., Kukrer, S., Uncumusaoglu, A., 2012. Nutrient and chlorophyll a trends after wastewater treatment plant in İzmir Bay (Eastern Aegean Sea). *Journal of Animal and Veterinary Advances,* 211(1):113-123.

Tuğrul, S., Uysal, Z., Erdoğan, E., Yücel, N., 2011. Changes of Eutrophication Indicator Parameters (TP, DIN, Chl-a and TRIX) in the Cilician Basin (Northeast Mediterranean) *(in Turkish with English abstract). Ekoloji, 20*(80): 33-41.

Tuğrul, S., Yemencioğlu, S., Doğan-Sağlamtimur, N., 2007. Monitoring of long term trends of the pollution sources of Mediterranean Coastal Area; Rivers and wastewaters (2003-2006) (in Turkish). *Turkish Journal of Aquatic Life*, 5(6): 596-606.

Yılmaz, A., Bastürk, Ö.,Saydam, C., Ediger, D., Yılmaz, K., E. Hatipoğlu, 1992. Eutrophication in İskenderun Bay, North-eastern Mediterranean. *Science of the Total Environment, Supplement 1992,* 705-717.